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MEMO FOR: Distribution

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SUBJECT: 2001 Summary of the Precipitation Program in SAB

## **BACKGROUND AND CURRENT STATUS OF PROGRAM**

The Satellite Analysis Branch (SAB) of the National Environmental Satellite, Data, and Information (NESDIS) provides quantitative satellite precipitation estimates (SPE's) and satellite guidance to the National Weather Service (NWS) whenever heavy convective rains threaten to produce, or are producing flash flooding. This is done for the lower 48 states and occasionally for Puerto Rico. Estimates are also provided for significant heavy rains and heavy snow with winter storms, and for heavy lake effect snows. The estimates are sent as part of the satellite-derived precipitation message (SPENES) on the Advanced Weather Interactive Processing System (AWIPS). SPENES is the AWIPS ID, and the WMO header for this message is TXUS20 KWBC. The SPENES message also contains guidance on satellite analysis, trends, and short range forecasts. Satellite estimates and guidance messages use GOES infrared (IR) and visible imagery; and messages also contain information from GOES water vapor imagery, GOES derived products and Sounder data, Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I) microwave data, and NOAA-15 & 16 Advanced Microwave Sounder Unit (AMSU) data, as well as blends of various satellite data. The first 2 attachments are samples of SPENES messages sent during 2001.

Satellite precipitation estimates are produced by the Automatic Rainfall Estimator (Auto-Estimator or AE) and the IFFA (Interactive Flash Flood Analyzer). The Auto-Estimator has been the primary source of operational rainfall estimates since June 2000. The AE was used 77% of the time in 2001 for satellite rainfall estimates, and the IFFA was used for the remaining times for which estimates were produced. The Auto-Estimator was developed by Dr. Gilberto Vicente, Office of Research and Applications (ORA)/NESDIS, to automatically produce rainfall estimates every half hour for the entire continental U.S. (CONUS) using the GOES IR imagery. It uses an algorithm based on IR cloud top temperatures and changes in temperatures to determine an instantaneous rainfall rate. Instantaneous rates derived every 15 minutes are combined to produce continuous products of hourly and 3 hour estimated totals for the whole U.S. every 30 minutes, 6 hour totals every hour, and 24 hour totals at 12Z. Corrections are also applied to the

estimates for parallax (satellite viewing angle), available moisture, and orographics. In addition, radar reflectivity screening is used as a rain/no-rain discriminator, and an automatic equilibrium level (EL) adjustment from the Eta model is applied to warm top convection. Using the Auto-Estimator for operations allows the SAB Meteorologists to produce more SPENES messages for heavy rains and flash flood guidance, and to cover more heavy rain events. The timeliness of SAB rainfall estimates and SPENES messages also improves using the Auto-Estimator compared with the IFFA operations.

The Auto-Estimator works well for most cold top convection during the summer season and is used for operations. However, the AE does not work well for most winter storm, snowfall estimates, and for some warm top convection. As a result, it is up to the judgment of the SAB Meteorologists based on his experience which system (AE or IFFA) is best to use for SAB Precipitation Operations.

The quantitative estimating techniques developed by Dr. Rod Scofield of ORA, and modified by SAB meteorologists, are used on the IFFA for convective rains and winter storms for which the Auto-Estimator is not used. A NESDIS in-house technique developed by SAB is used for lake effect snows. The techniques use cloud top temperatures and satellite signatures on the imagery to determine hourly and half hourly estimates from a series of animated IR and visible images. The IFFA is a man-machine interactive system where estimates are done manually and then stored and totalled for whatever time period is needed. An orographic correction is applied to the estimates for time periods of 9 hours or less in the mountainous areas of the western U.S. and the Appalachians.

The IFFA and AE rainfall estimates are put onto the Internet as a graphical product on the SSD homepage. The WWW address for the homepage is: <http://www.ssd.noaa.gov>, and the estimate graphics can be found under the operational products and services. The SPENES messages are also there. The graphics are available in real-time and are estimates for short time periods such as 3 and 6 totals and are usually paired up with a particular SPENES message.

## **The NPPU**

The SAB precipitation operations are collocated with the Hydrological Prediction Center (HPC) of the National Center for Environmental Prediction (NCEP) in what is called the National Precipitation Prediction Unit (NPPU) in the NOAA Science Center. The SAB precipitation meteorologists give HPC forecasters 6 regularly scheduled satellite briefings per day as input for their Quantitative Precipitation Forecasts (QPF's) with special emphasis on heavy precipitation and short range trends. Big changes have occurred in the suite of HPC QPF products over the past 1-2 years. SAB has made adjustments to the time and contents of the scheduled briefings in order to provide maximum satellite input corresponding to the HPC products schedule. All of the satellite products that are available for input into the SPENES messages are also used in briefing HPC as input for the HPC QPF's, excessive rainfall potential outlooks, and heavy snow forecasts. Additional unscheduled briefings are given to HPC by the SAB precipitation meteorologists any time there is new satellite data available that would be of value in analyzing or forecasting heavy precipitation. SAB and HPC have had this close working relationship since 1993 in the NPPU, and the satellite input has been very important for the HPC operations.

## **2001 HIGHLIGHTS**

### **Operational Improvements**

During 2001, the SAB precipitation program continued making improvements in the operational use of the Auto-Estimator. A second version of the AE was included in the operations beginning in June. It is called the Hydro-Est (H-E) and was developed by Clay Davenport, a contractor working with Rod Scofield's Hydrology Team in ORA. The H-E version has a slightly different algorithm for satellite rainfall estimates that assigns rain rates not just by cloud top temperature and growth at each picture element, but assigns it relative to temperatures and growth around each element. It was evaluated by SAB Meteorologists over the past year and performs better for very cold cloud tops and for large convective complexes, and also may improve estimates for warm convective cloud tops and winter storms. In addition, we now have the capability of adding up estimated rainfall totals for the H-E for any time periods, not just the standard 1, 3, and 6 hour periods.

Now the SAB precipitation Meteorologists can choose between the original operational AE and the new H-E version according to which is producing better estimates. As a result, the AE is able to produce operationally useable estimates more frequently. In 2001 the AE was used for operational rainfall estimates 77% of the time which is an increase from 64% in 2000. This also contributed to increased production of SPENES messages and record high totals for August and November.

Other significant operational improvements in the NPPU included: continued intergration of AWIPS into precipitation operations; AMSU-B data became operational in the NOAA Science Center (NSC)/NPPU which provided higher resolution rain rate data from an improved algorithm; NOAA-16 began operations providing AMSU data every 6 hours; and the experimental use of areal Tropical Rainfall Potential (TRaP) for tropical systems approaching the U.S. continued with several improvements.

During the 2001 hurricane season, the SAB precipitation program (in cooperation with the SAB Tropical Team) continued issuing experimental areal TRaP's using SSMI rain rate data for tropical systems approaching the U.S. TRaP's using SSMI were put onto the SSD Internet Web page making them widely available for potential users such as the Tropical Prediction Center and NWS Forecast Offices. SAB also now has the capability of doing TRaP's experimentally using AMSU, AE, and rain rate data from the NASA Tropical Rainfall Measuring Mission (TRMM) satellite, and will be able to send any of these to the Internet for the next hurricane season. In addition, funding is now available and work has already begun to make TraP an operational product for future distribution.

Also during 2001, the Precipitation Team continued evaluating several ORA experimental products in order to aid ORA in their development and possible future operational use. They included: an AE version of a lake effect snow estimator; and a version of the H-E that does not used a radar correction and which will be available on AWIPS sometime in 2002. In addition, the Team assisted Bob Kuligowski of ORA in his ongoing evaluation study of all the ORA satellite estimating algorithms.

## **Rainfall Patterns for 2001**

Attachments 3, 4, 5, and 6 show production statistics for 2001. The following discussion highlights some of the major weather patterns of the year which are reflected in the production statistics. The La Nina of the previous year ended in 2001 and, as a result, normal rainfall returned to much of the South except for the Southeast. Drought conditions continued over Florida into May which resulted in numerous wildfires in the late winter and spring. The increased rainfall over Texas was excessive at times and there were several big flash flood events in parts of Texas in June, August, and November. The major flooding in Texas in June was caused by Tropical Storm Allison which was the costliest tropical storm in U.S. history. There was \$5 billion in damages in southeast Texas and Louisiana and the storm took 41 lives. Not only was Texas affected by Allison and its remnants, but there were several big flash flood events along its 17 day path which stretched from east Texas to the Middle Atlantic states between June 5 and June 17. The drought finally began to ease over Florida with the return of heavy summertime showers and the beginning of the rainy season in June. Tropical Storm Barry brought heavy rains to the Panhandle in August, and Tropical Storm Gabrielle affected the Florida peninsula in September. Tropical Storm Dean brought heavy rain to Puerto Rico in August, but no hurricanes hit the U.S. mainland in 2001.

In the West, there were frequent winter storms into California during the winter of early 2001. Excessive rainfall with these storms caused one flash flood event in southern California in February, and an even bigger flash flood event in the beginning of March. Meanwhile, the Pacific Northwest received quite a few winter storms but precipitation totals were light resulting in drought conditions in the northwestern U.S. and leading to a very active summer fire season in that area. However, the winter season of late 2001 saw a return of winter storms with heavy precipitation into the Pacific Northwest which alleviated the dry conditions and led to some major river flooding in western Washington state by December. The summer monsoon season in the Southwest was brief but very active this year. Most of the heavy showers were concentrated in just the months of July and August. The large number of SPENES's sent for summer monsoon rains, particularly for Arizona, also contributed to record high totals for August.

In the East, there were several winter storms in the Northeast in the winter of early 2001, and rainfall was mostly adequate in the summer. There was significant flash flooding in spots from eastern North Carolina northward to eastern Pennsylvania and southern New England in June from the remnants of Allison, and major flash flooding occurred in southern West Virginia in July. However, the spring and fall seasons were dry and in some places there was record dryness from the Northeast to the Middle Atlantic states resulting in drought conditions in many areas. The beginning of the winter season at the end of 2001 saw an absence of winter storms in the East except for a spell of some extreme lake effect snows at the end of December. Buffalo set several snowfall records, and there were also extreme snowfall amounts to the east of Lake Ontario. The central U.S. was dry in the beginning of 2001 but began to pick up normal convective rainfall into spring and summer over most of the area. There were several noteworthy isolated flash flood events from Kansas and Missouri northeastward to Wisconsin and Michigan between May and August.

Once again this year, the SAB Precipitation Program provided some support for heavy rains in Hawaii. Normally we do not support Hawaii because the rains there are very isolated and orographic, and satellite estimates cannot be done because of the very small scale nature of the events and very warm infrared cloud tops. But occasionally a “kona low” taps into deep tropical moisture and produces heavy showers with colder tops. This happened last year in November when record rains fell, and once again flooding rains occurred in November 2001. SPENES messages were sent containing satellite guidance and some rainfall estimates, and some phone call coordination was done for this event.

## **Production Statistics**

The production of SPENES messages continued high in 2001, only down slightly from the record number of messages in 2000 (see Attachment 5). This increased output was noted in 2000 with the introduction of the Auto-Estimator into operations in June 2000. And although the total number was down, the number of SPENES's per man-hour remained the same at .6 SPENES's/man-hour (computed from Attachment 5). And so we can see that the increased productivity using the AE continued in 2001 which also means more messages per heavy precipitation event and more events covered compared to the years before 2000.

Looking closely at the individual graphs, Attachment 3 shows the normal maximum of SPENES's during the summer months which was increased to stretch throughout the entire season by the heavy rains with Allison in June, and by the heavy rains in Texas in August which led to a record high total for that month. The overall totals were lowest during the fall and winter months as is normal, but notice several interesting maximums there. First of all, a distinct maximum occurred in the late winter when the number of messages increased in February and March due to a continuous succession of winter storms into California and heavy rains in the South particularly in Texas. Another maximum occurred at the end of the year as the number of SPENES's peaked into November and December. Totals for each of these months were record highs for the month. The November totals were high because of numerous messages sent for the heavy rains in Texas along with the winter storms into the Pacific Northwest, and the large December totals were due to the record lake effect snows in New York at the end of the month and the continuation of winter storms into the Pacific Northwest.

The number of hours monitoring and estimating (man-hours) on the graph in attachment 4 shows a pattern throughout the year similar to the SPENES graph. The only difference is the drop off of man-hours toward the end of the summer in August. That was the month in which Texas had heavy rains and flash flooding, and was also the height of the summer monsoon season in the Southwest. Since summer monsoon heavy rain events are frequent but short-lived, that is probably the reason the number of man-hours decreased while the number of SPENES's remained high.

The graph in attachment 5 shows the trends in yearly totals for the past 10 years for SPENES messages and for man-hours. The increased productivity for 2000 and 2001 because of the AE has already been noted. Also notice the steady increase in SPENES production since 1996. One reason was increasingly wet weather through 1998 due to the El Nino. Although drier weather

returned to much of the U.S. in 1999, production of messages did not drop off much. Another reason for the steady increase is the effort in SAB since 1996 to provide more frequent SPENES messages, not only for rainfall estimates but also as flash flood guidance even when there are no estimates. The more frequent messages (mostly for winter storms) are sent as a result of an NWS request for more guidance, particularly for winter storms into the U.S. West Coast. These messages make heavy use of SSM/I and AMSU microwave data (rain rates and precipitable water) and analysis of GOES imagery and GOES Derived Product Imagery and Sounder products. In addition, there has also been an increasing number of SPENES's sent for lake effect snows in recent years. Also, while the number of SPENES messages was increasing over the past 5 years, the number of man-hours monitoring and estimating has fallen off showing increased productivity as mentioned earlier.

The tables of the top ten states receiving SPENES messages and the distribution by NWS regions (see attachment 6) shows that Texas and the Southern Region were the leaders as usual in 2001. The percentage for the Southern Region has increased quite a bit over last year with a return to normally wet weather there after the end of the La Nina. Notice that 4 Southern Region states are in the top ten. California made second place due to frequent winter storms in both the beginning and end of 2001. And Washington and Oregon are in the top ten mainly because of winter storms at the end of the year in the Pacific Northwest. Washington did not even make the top ten last year when there was a drought in that area. Arizona is there mainly because of the summer monsoon, and most of the rains that put Kansas and Missouri in the top ten fell in the active spring through summer period. The most dramatic change in the percent distribution by NWS Region was in the Eastern Region which fell as extremely dry conditions set in at the end of the year from the fall into the winter.

And finally, in an effort to better quantify our precipitation operations, for the past 2 years we have been keeping track of the number of heavy precipitation weather systems for which SPENES's have been sent. For our statistics we track and log distinct weather systems as seen on the satellite imagery. Many systems do not develop into big storms and only 1 message is sent. Some systems are long-lived storms (Allison for example) for which many messages are sent. Large long-lasting storms can also generate several heavy precipitation systems as areas of heavy precipitation develop and dissipate on the satellite imagery. The total number of heavy precipitation systems for 2000 is 855, and the total for 2001 is 847 systems. These numbers are just about the same and slightly lower for 2001 which is what we also see in the totals for man-hours and SPENES's. This averages to around 2.5 messages per system. There is no table or graph attached for this statistic.

SAB's Precipitation Team consists of: Rich Borneman, Sheldon Kusselson, Chuck Kadin, Tom Baldwin, and John Simko.

Attachments

Distribution:

E/RA - A. Gruber/F. Holt  
E/RA21 - R. Scofield/R. Kuligowski  
E/SP - H. Woods/M. Matson  
E/SP2 - R. Lawrence  
E/SP22 - J. Paquette  
E/SP23 - S. Young  
W/NP - L. Uccellini  
W/NP3 - D. Reynolds/E. Danaher  
W/OM21 - T. Graziano  
W/OM22 - J. Heil

SATELLITE PRECIPITATION ESTIMATES..DATE/TIME 6/9/01 0210Z  
SATELLITE ANALYSIS BRANCH/NESDIS---NPPU---TEL.301-763-8678  
VALUES ARE MAX OR SGFNT EST. NO OROGRAPHIC CORRECTION UNLESS NOTED...  
....EST'S FM:/GOES8-CNTRL AND E. U.S./GOES10-W. U.S...  
LATEST DATA USED: GOES-8 0145Z JS  
AUTOESTIMATOR: 0130Z

LOCATION...SOUTHEASTERN TEXAS/SOUTHERN MISSISSIPPI/WESTERN ALABAMA



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EVENT...LAKE EFFECT SNOWS OFF OF LAKE ERIE AND ONTARIO.

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SATELLITE ANALYSIS AND TRENDS...

.  
FOR LAKE ERIE SNOWS...BAND IS NOW STARTING TO MOVE NORTHWARD AGAIN. IT ALSO MAY BE INTENSIFYING AS CLOUD TOPS HAVE COOLED A COUPLE OF DEGREES IN THE PAST HOUR. HAVE BEEN ESTIMATING RATES IN THE 1.0-1.5"/HR RANGE FOR CENTRAL AND SOUTHERN ERIE COUNTY BUT MAY START BOOSTING THEM TO 2"/HR OR POSSIBLY EVEN HIGHER IF THIS ENHANCING TREND CONTINUES.

.  
FOR LAKE ONTARIO SNOWS...RATHER DISORGANIZED LOOKING BAND CONTINUES TO AFFECT JEFFERSON/N LEWIS/ST LAWRENCE COUNTIES WITH RATES ESTIMATED IN THE .5" TO POSSIBLY AS HIGH AS 1.5"/HR RANGE. ENHANCED CLOUD TOPS NOW COVER THE CENTRAL TO EASTERN PORTION OF THE LAKE SO THE POTENTIAL STILL EXISTS FOR SOMETHING MORE FOCUSED TO DEVELOP DURING THE MORNING.

.  
IFFA SATELLITE SNOW ESTIMATES SINCE 1415Z PAST 6 HOURS(0415-1015Z)  
NEW YORK COUNTIES...

N AND CENT ERIE	UP TO 23"	UP TO 8.0" (CENT ERIE)
S NIAGRA	8.5-12.5"	
SW ORLEANS/W GENESSEE	6.0-9.0"	2.0-3.5"
NW WYOMING/FAR N CHAUTAUQUA		2.0-3.5"
N CENT JEFFERSON/W CENT ST LAWRENCE	4.0-6.0"	UP TO 4.0"

.  
GRAPHIC OF SNOW ESTIMATES IS ON THE INTERNET AT THE ADDRESS LISTED BELOW.

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REFER TO NCEP/HPC DISCUSSIONS AND QPF/S FOR FORECAST.

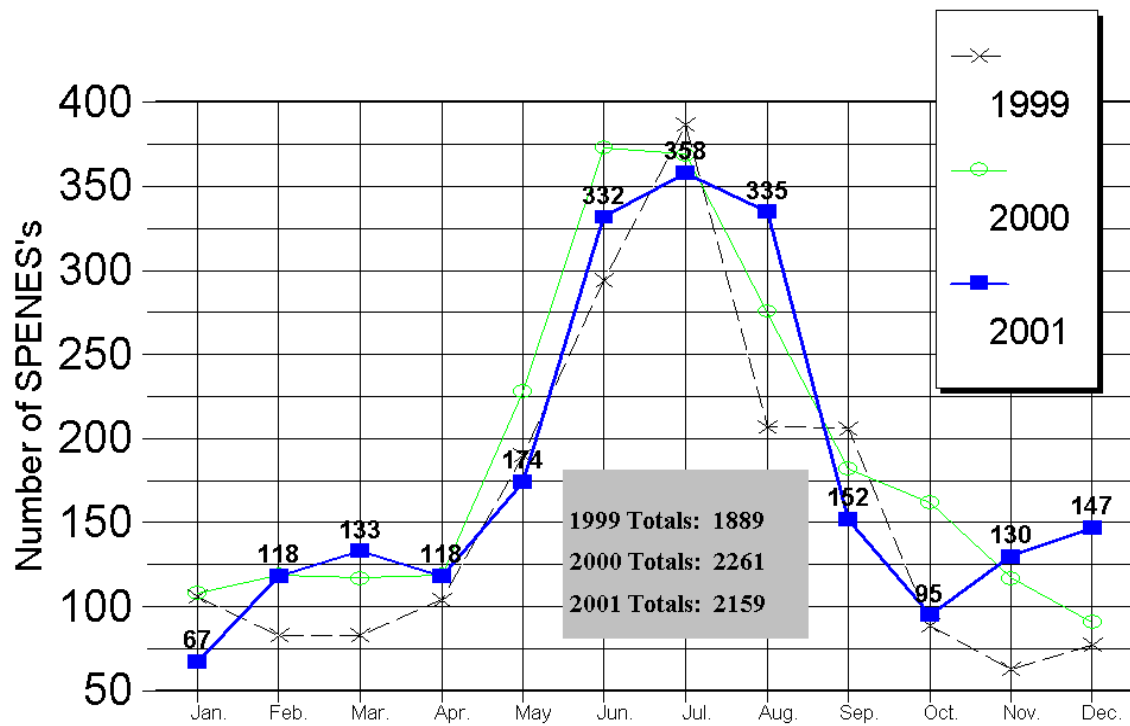
.  
[HTTP://WWW.SSD.NOAA.GOV/PS/PCPN/](http://WWW.SSD.NOAA.GOV/PS/PCPN/)  
...ALL LOWER CASE EXCEPT PS/PCPN...  
[ONLINE SSD PRECIP PRODUCT INDEX]

.  
**EXAMPLE OF SPENES MESSAGE FOR LAKE EFFECT SNOWS**

Attachment 2: Sample SPENES Message

# 2001 SPENES MESSAGES SENT

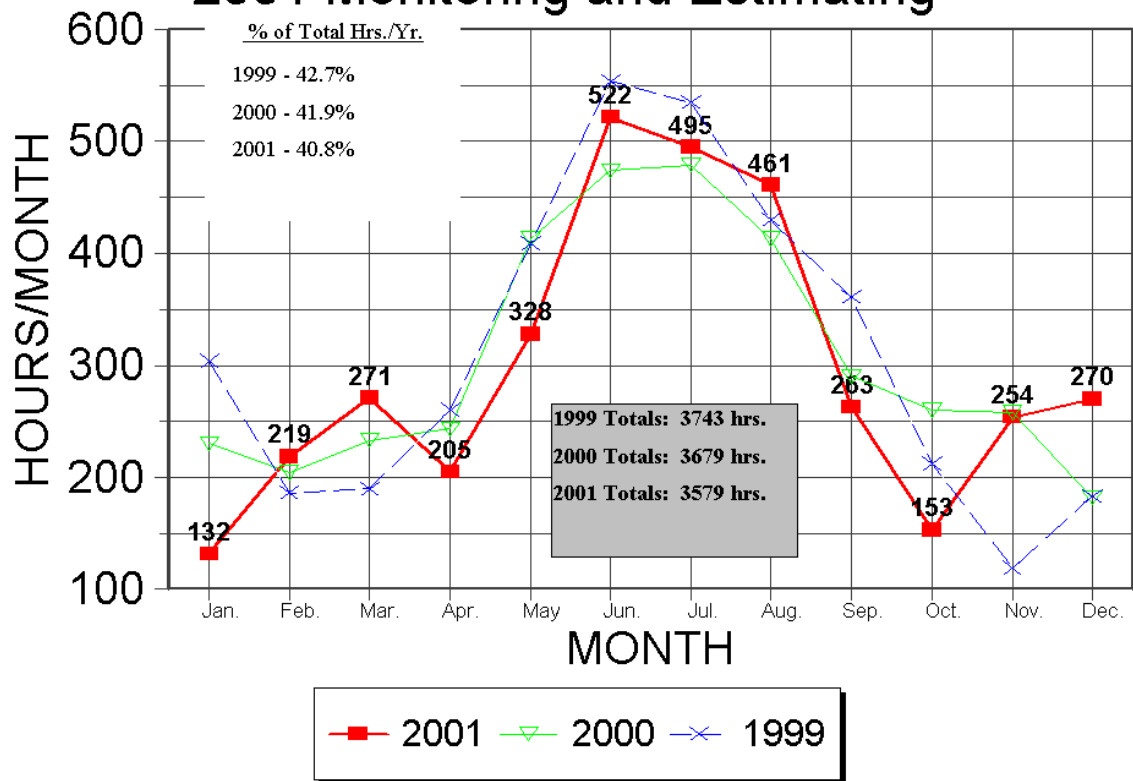
2001 Monthly Totals Labelled



Attachment 3: 2001 SPENES Production Statistics

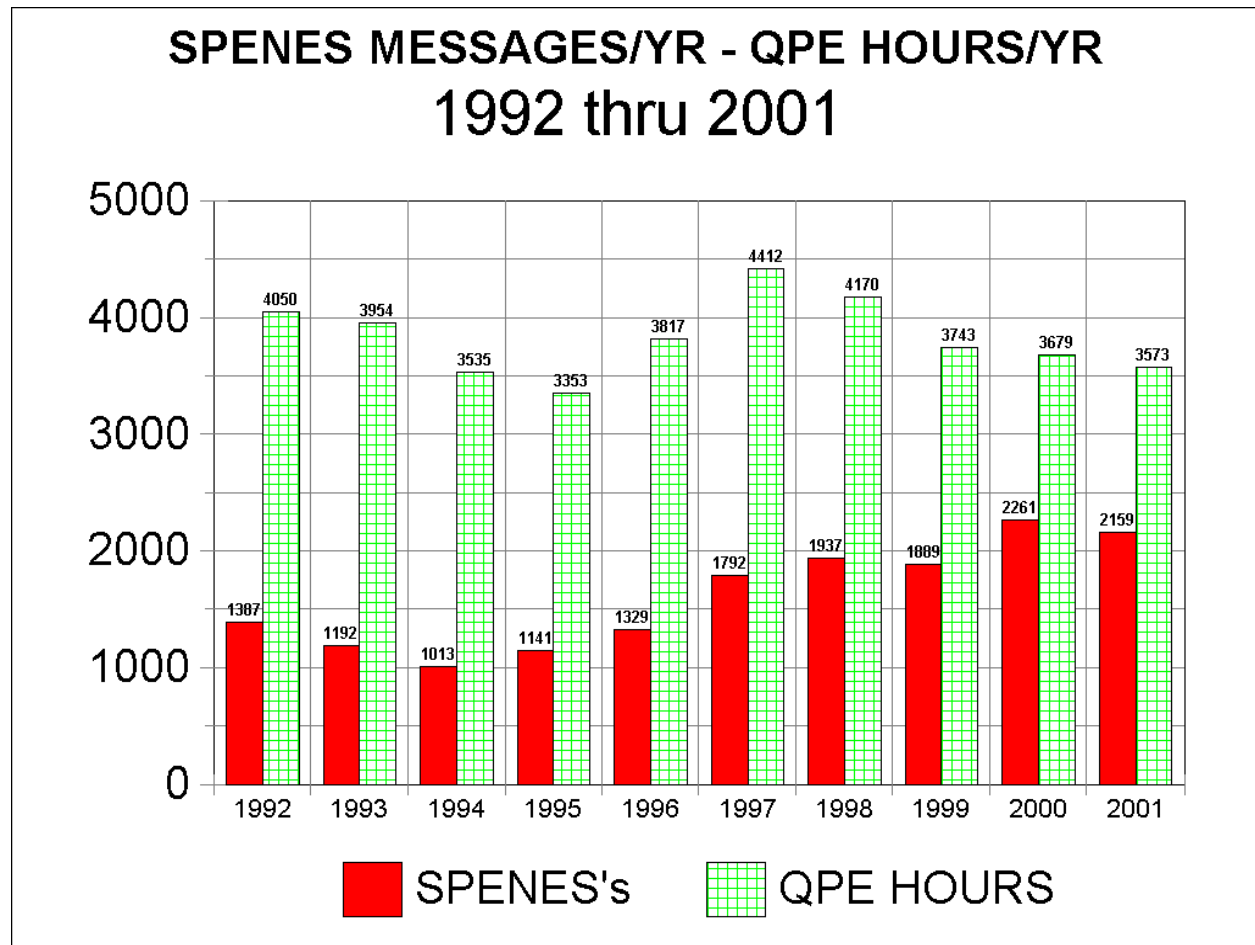
# PRECIPITATION HRS./MO.

## 2001 Monitoring and Estimating



Attachment 4: 2001 Hours of Monitoring and Estimating

Attachment 5: 1992-2001 Production Statistics



**TOP TEN STATES RECEIVING SPENES MESSAGES IN 2001**

<u>State</u>	<u>No. of SPENES's</u>	<u>Percent of Total</u>
1. Texas	443	13.4%
2. California	225	6.8
3. Louisiana	169	5.1
4. Kansas	144	4.3
5. Missouri	140	4.2
6. Arizona	139	4.2
7. Oregon	135	4.1
8. Mississippi	119	3.6
9. Oklahoma	117	3.5
10. Washington	104	3.1

### **SPENES DISTRIBUTION BY NWS REGION**

1. Southern Region	1324 SPENES's	40.0%
2. Central Region	850	25.7
3. Western Region	666	20.1
4. Eastern Region	473	14.3

Attachment 6: Distribution by State and NWS Region